THE ECONOMICS OF LARGE-SCALE COMPUTER TECHNOLOGY

INPUT

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A. CENTRALIZATION VERSUS DECENTRALIZATION

- In 1976 INPUT published Economics of Computer/Communications Networks and Their Future Impacts, which presented a case study showing the cost savings that could be achieved by consolidating multiple computer systems into a large host-oriented, hierarchical network. The results are summarized in Exhibit I.

  - Total cost was reduced by 48% from \$16.1 million to \$8.3 million.

  - Computer hardware cost was reduced by 69% from \$8.9 million to \$2.8 million.

  - Personnel costs were reduced by 48% from \$3.6 million to \$1.9 million.

  - Other operating costs (space, power, systems software, etc.) were reduced by 62% from \$3.6 million to \$1.4 million.

  - These savings were achieved despite new expenses of \$2.3 million for data communications services (\$1.6 million) and terminal equipment (\$0.7 million) to establish the communications network.

- Based on this case study, INPUT concludes that substantial savings in data processing expenses could be achieved by consolidating smaller, standalone systems onto advanced large-scale mainframes in a properly designed hierarchical network. Analysis of the savings revealed the following general principles associated with the proper design of such networks:

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EXHIBIT 1

THE STANDALONE VERSUS NETWORK CASE STUDY RESULTS

($ Thousands)

1970 1971 1972 1973 1974 1975 1976

Hardware		
Number & Type	20 - IBM 370/115's Through 370/158's	2 - IBM 370/168's
Rated Performance	45.4X IBM 370/135	22X IBM 370/135
Cost	$ 8,900	$2,782
Data Communications Cost	Negligible	1,590 (service) 738 (terminals)
Personnel Cost		
Central	--	1,126
Nodes	3,593	725
Other Operating Costs		
Central	--	1,126
Nodes	3,593	242
Total Cost	$16,086	$8,329

1970 1971 1972 1973 1974 1975 1976

- Economy of scale did in fact exist, and the large systems provided substantially more effective computer power than smaller systems (better price-performance).

- There is a "replacement phenomenon" that demonstrates that large systems can actually replace twice as many small-scale systems than would be indicated by internal performance ratios (the two 370/168s replaced systems with more than double their rated performance). This phenomenon occurs because of scheduling and resource allocation problems inherent in multiple and/or decentralized systems.

- There is substantial overhead (in terms of personnel and other operating costs) associated with each additional console (system) that is operated.

- All of the above argues for using the largest possible mainframes as host systems in computer/communications networks.

• INPUT has consistently argued for centralization on large host systems, with subsequent "orderly" distribution of processing to minicomputers and intelligent workstations. Despite advances in minicomputers and microprocessor development, this has remained our position; it is our opinion that advances in mainframe price-performance will continue to warrant applying "top-of-the-line" hardware at the central facility.

B. THE CASE STUDY GROWTH SCENARIO

• The computer site studied in 1976 has been growing by approximately 25% per year in terms of required processing power. The assumptions for two strategic scenarios are presented in Exhibit 2. One is labeled the 370/168 strategy, and it assumes the company will decide to "freeze" on that tech-

EXHIBIT 2

GROWTH SCENARIO ASSUMPTIONS

1977 1978 1979 1980 1981 1982 1983 1984

Capacity Requirements (2-370/168's=1)	1.25	1.56	1.95	2.44	3.05	3.81	4.77
Mainframes Installed							
370/168 Strategy	2-168's	3-168's	4-168's	5-168's	6-168's	8-168's	10-168's
"Leading Edge" Strategy	2-168's	1-168 1-3033	2-3033's → (Based on "Replacement Phenomenon")			2-3081's →	
Personnel Expenses							
370/168 Strategy		+5%	+5%	+5%	+5%	+10%	+10%
"Leading Edge" Strategy		Remains the Same - Same Number of Consoles					
Operating Expenses							
370/168 Strategy		+25%	+15%	+12.5%	+10%	+15%	+12.5%
"Leading Edge" Strategy		Remains the Same - Same Number of Consoles					
Mainframe Hardware (Processors)							
370/168 Strategy	Purchase Additional Systems at Used Market Retail						
"Leading Edge" Strategy	Sell Old at Used Market Wholesale Write-off Any Excess Book Value Purchase New at List						

nology. The other is labeled the "leading edge" strategy, and it assumes early installation of the largest available IBM mainframes.

- Under the 370/168 strategy, additional capacity will be purchased in the used computer market as required.

- Under the leading edge strategy, the largest system available will be purchased at list from IBM (although the strategy might be enhanced by the use of Amdahl systems). The objective is to maintain two systems installed, and a replacement ratio of 1.5 (as opposed to the 2.0 achieved in the case study) is assumed. (This means that a large system will replace 1.5 times the number of smaller systems indicated by the internal performance ratios.) "Obsolete" equipment will be sold on the used market at wholesale prices and any excess book value will be written off.

- By maintaining two consoles, it is assumed that personnel requirements and other operating expenses will remain the same under the leading edge strategy. Conservative increases in personnel and operating expenses are assumed for the 370/168 strategy based on the installation pattern of additional systems.

    - Personnel expenses are assumed to increase by 5% for each additional system installed.

    - Operating expenses are assumed to increase at approximately 50% of the percentage increase in the number of systems.

    - Both of these assumptions result in increases that are lower than would be indicated from the conservative results of the case study.

- The scenarios are played out for mainframes only, based on the assumption that other hardware expenses for peripherals and disk storage are comparable. This, too, is conservative since new peripherals and storage devices frequently are not made available on older systems. The results are presented in Exhibit 3. It should be emphasized that the scenarios are not intended to be a financial model. The purpose is to present a conservative estimate of the operational costs of freezing on mainframe technology in a growth environment.

  - Personnel expenses for the 370/168 strategy would rise to be 47% more than for the leading edge strategy by 1983.

  - Operating expenses in 1983 for 10 370/168s, as opposed to two 3081Ks, would increase by 130%. (Over five times the floor space, power, and plumbing would be required.)

  - The hardware expenses (processors only) vary from year to year, but over the length of the scenarios the total hardware cost for the 370/168 strategy is 10% higher at $12.9 million than the leading edge strategy at $11.7 million. The method of determining hardware cost was simplified (since it did not include interest, ITC, etc.) and will be briefly explained, but the point is that personnel and operating expenses under 370/168 ($4.25 million) exceed the total cost under the leading edge strategy ($4.16 million). The following are comments concerning hardware costs:

    - All hardware was assumed to be purchased as indicated in Exhibit 2, and hardware cost was merely the depreciation plus maintenance.

    - The initial two 370/168s were depreciated over a seven-year period (the actual situation in the case study), and all other 168s were written off to be fully depreciated in 1983.

EXHIBIT 3

COST COMPARISON SCENARIOS

(Mainframes) ($ Thousands)

	1977	1978	1979	1980	1981	1982	1983
370/168 Strategy							
Personnel	$1,126	$1,182	$1,241	$1,303	$1,369	$1,506	$1,657
Operating Expense	1,126	1,408	1,619	1,821	2,003	2,304	2,591
Processor (Number)	(2)	(3)	(4)	(5)	(6)	(8)	(10)
Hardware Cost (including maintenance)	1,048	1,424	1,800	1,934	2,156	2,566	1,986
Total	$3,300	$4,014	$4,660	$5,058	$5,528	$6,376	$6,234
"Leading Edge" Strategy							
Personnel	1,126	1,126	1,126	1,126	1,126	1,126	1,126
Operating Expense	1,126	1,126	1,126	1,126	1,126	1,126	1,126
Processor Hardware Cost (Including maintenance	1,048	1,750	1,928	1,552	1,534	2,001	1,910
Total	$3,300	$4,002	$4,180	$3,804	$3,786	$4,253	$4,162

- The 3033s and 3081s were depreciated over a five-year period.

- The cost of 168s in the used market ranged from $2 million in 1977 to $200,000 in 1983.

- The 3033s were purchased for $3,400 each (in 1978 and 1979) and the 3081s were purchased for $4,680 (at the end of 1982).

- Write-offs on the sale of 168s were taken in 1978 ($570,000) and 1979 ($352,000), and on the sale of 3033s at the end of 1982 ($484,000); these are included in the hardware expense figures for those years.

- In addition, the leading edge scenario has resulted in a state-of-the-art facility, which has many advantages (with one being easy growth).

- On the other hand, the 370/168 strategy has reached the end of the line with hardware that must be scrapped, excess space, operational problems (probably including incompatible operating systems environments across the multiple mainframe systems), and conversion problems that might literally be impossible to solve.

- The scenario is obviously exaggerated--it is assumed that no one would get themselves into such a technological mess. However, it must be remembered that the bargains in the used market do beckon, and INPUT has pointed out in its Residual Value series of reports that on a "cost-per-MIPs basis" the used market does provide attractive alternatives in certain situations. However, the leading edge strategy appears to be financially justified when the advantages of large mainframes in the operational environment are considered (and/or understood). In addition, there are other compelling arguments that are real in actual practice and can substantially increase the cost of "staying in the trough of technology" as opposed to being on the leading edge.

- The desirability of remaining reasonably current with IBM systems software has been mentioned before but can bear repeating. The headaches of maintaining multiple systems are well known; it is expensive because more systems programmers are required, and they are difficult to find under the best of circumstances.

- This brings us to another fact that is usually played down but that is nevertheless important: it is difficult to find systems programmers or operations support people who want to work with obsolete hardware and systems software. INPUT's research reveals that the quality of personnel is extremely important in productivity improvement (much more so than tools and aids). The cost of lower quality personnel and turnover should not be underestimated.

- As more complex environments are created in order to satisfy user requirements, the demands on central mainframes have grown substantially. Indeed, mainframe technology (in terms of performance) frequently does not keep up with demands for terminal response time or the management of large data bases. It was discovered that many large IMS data bases could not be reorganized on 370/168s because the processor was not powerful enough. The 370/168 strategy would have dictated changing the application (user requirements) rather than solve the problem with new technology. INPUT has warned that processing power on large central mainframes (top of the line) will be needed by the environment emerging during the 1980s. This is not generally understood because of the current fascination with microprocessor development.

C. THE CRITICAL NATURE OF TODAY'S ENVIRONMENT

- INPUT's Large-Scale Systems Directions reports for this year have described the environment as we see it emerging in some detail. The conclusions are briefly summarized here.

  - The microprocessor may develop into a desktop mainframe with a high MIPs rating per dollar, but it is not going to replace (or even impact) the need for large-scale, host systems in the immediate future (throughout the 1980s). One reason is that intelligent workstations (PCs) are not being utilized effectively (you don't need MIPs to do text editing or to run a spreadsheet), and the other reason is that data is not currently available to make use of the raw processing power.

  - The "solution" of micro-mainframe links is not currently very well understood, but one thing is certain: heavy processing demands are going to be made on the central mainframes. In addition, the concept of having intelligent workstations "dip into corporate data bases for data" has inherent problems of data base synchronization, integrity, and security that could result in a general lowering of corporate information quality.

  - After years of being critical of IBM's heavily host-oriented SNA environment, INPUT now believes it is necessary if chaos is to be avoided. Central control is essential, and IBM's highly centralized SNA provides a cautious approach necessary to restrain the development of unworkable systems.

  - The demand for more powerful processors will come from several sources:

- Analysis tools of operating research and the modeling of complex artificial systems (such as the economy) requiring extremely heavy processing.

- The management of large data bases (especially with DB2) require extremely heavy processing of tables and indices.

- If knowledge-based system concepts are to be applied to the decision-making process, exceptionally heavy and unpredictable processing demands will be made on the central processor (for the reasons stated above).

- It all points to unprecedented demand for a new level of processing capability at the host system, and it may be that new hardware architecture will be required to meet these demands. Even with improved hardware systems life cycles, the power may not keep up with the applications demand.

- It is INPUT's belief that it is of critical importance to analyze and anticipate these processing requirements because they are not generally understood. It is our opinion that two major problems can arise if the need for processing power is not anticipated.

  - Unworkable systems may be developed because processing power is not available. This will be not only embarrassing but also very expensive.

  - Information quality will degenerate (and perhaps quite rapidly) if processing power to control data entropy (see INPUT's executive bulletin on data entropy) is not sufficient. This could have highly unfavorable or even catastrophic impact in today's competitive environment.

- There is a precarious balance between the availability of sufficient processing power from new technology, and the orderly distribution of processing under the SNA umbrella. It is hoped that IBM has not miscalculated in their timing; they are currently in control of the release of new hardware/software technology, and everyone is more or less dependent on their schedules.

D. INPUT'S PROJECTED IBM TIMING

- IBM is currently committed to a highly centralized (SNA) strategy necessary to integrate rapidly developing microprocessor-based intelligent workstations. Both Sierra and Summit will be required during the 1980s to meet these demands, and pressure upon mainframe power will continue through the 1980s.

- It will not be until the 1990s that functional and architectural differentiation and mechanization will relieve the reliance on large host processors under IBM's plan. After that time, specialized systems and processors should obsolete the classic von Neumann general-purpose processor.

- Until then, INPUT strongly recommends that major corporations stay up to date with computer/communications technological advances. INPUT sincerely believes this is of critical importance if unpleasant surprises are to be avoided and organizations wish to position themselves to take advantage of promised improvements in productivity.